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ANALYSIS OF COMPOSITE ORTHOGONAL GRID STIFFENED FLAT PANEL

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Original Article

ABSTRACT

Composites offer strength to weight ratio which is necessary for a aerospace industry. Commercial aircraft flooring is about 1cm thick, 2ft by 4ft in size and is made of glass or carbon fiber reinforced epoxy skins with a nomex honeycomb core. The use of sandwich construction, is efficiently the most structurally efficient component. The substitution of Advanced Grid Stiffened (AGS) structures is not required in reducing structural weight, but at reducing cost factor. Advanced structures are characterized by a lattice of rigid, interconnected ribs, which proves to be a highly efficient design. AGS structures also offer other inherent advantages such as high impact resistance, when damaged, delamination and crack propagation tend to remain isolated to a cell. Commercial aircraft floors are designed to withstand high compression loads. The project deals with Design and Analysis of a flat panel of sizes 410mm X 410mm with an orthogonal grid, 4 longitudinal and 4 transverse stiffeners of 10mm width and 14mm height has been considered. The flat panel has been designed and structural analysis is carried out by using ANSYS Software for two different types of materials (Carbon/epoxy, glass/epoxy).

KEYWORDS: Grid Stiffened Panel, Composite Analysis & Advance Grid Structures

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1. INTRODUCTION

Combining a few segments to deliver another material with new properties that are not achievable with singular parts is not of the late root. People have been making composite materials to fabricate more grounded and lighter articles for many great years. Composites business is developing with a great part of the development which is currently engaged around a sustainable power source. Later on, composites will use far and away superior filaments and thus a considerable lot of which will fuse Nano-materials. Thin walled structure or plate like components(un-stiffened) are typically encountered in ships, aircraft, submarine, and bridge construction. In engineering structures, for structural potency and conservation of weight with no loss of strength most of the skinny walled structures square measure stiffened are encountered. As a result of this skinny walled or un-stiffened structure subjected to varied sorts of load similar to compression, biaxate compression, pressure load, bending moment and cut load etc. lead to buckling, because of which failure of skinny walled or un-stiffened structure happens. The common things to increase the buckling resistance of un-stiffened structure could be either to extend the thickness of the structure or by the supported total economy. That's the value for increasing the online thickness of un-stiffened structure; which lead to a significant weight product. On the opposite hand reinforcing the skinny walled structure with light-weight stiffeners reduces the value and likewise its weight. Designer's area unit is mostly involved in concerning light-weight, weight structural performance and potency. So rather than increasing the thickness of un-stiffened structure for interference of buckling, Filler conjointly referred to as stringer or beam

is used. It's a kind of beam that is placed in longitudinal or crosswise direction and a range of stiffeners is made-up over the plate cherish flat bar, hat type, I-section, T-section and angle section. Because of this, benefits of light-weight, tiny producing value, high strength, high stability, nice energy absorption and superior harm tolerance are achieved; grid-stiffened panels are applied in region engineering for payload fairings of launch vehicles and for supporting structures of satellites [3]. A stiffened composite structure consists of the huge variety of structural elements akin to skin, stringers, spars, ribs. For connection of these parts along, it needs mechanical fastening method. In homogenized or typical gilded material such fastening method is not of high price; however, there's downside of fatigue and corrosion that requires expensive treatments and periodic inspection. Thanks to this within the starting of Sixties the implementation of composite materials in stiffened structure makes it attainable to beat issues relating to gilded material. The employment of advanced composite materials is accumulating in numerous structures akin to in marine, region and civil. The very important distinction between composite and gilded materials is to realize the foremost effective mechanic properties akin to strength, membrane and bending stiffness, etc., by dynamical lay-up configuration and variety of layers. Therefore, the laminated composite plates are thought of, because of the basic modules, in high performance boats, craft and plenty of alternative advanced structures that need higher sturdiness, less specific weight, and wonderful harm tolerance and are typically subject to air-blast loading or below water shock [6]. The elastic buckling and buckling strength analysis of the stiffened plates subject to the in-plane loading is very important in structural design and analysis [7]. El-Sawy and Nazmy [17] employed the finite element methodology to work out the elastic buckling load of uniaxially loaded rectangular perforated plates with circular, rectangular and serpentine corner for ratio of one, two, three and four below merely supported edges. The results show that the buckling constant k of an oblong plate with associate number ratio isn't same as sq. plate with holes and plate with a hole at the centre would cut back the steadiness of structure. Pavlovcic et al. [19] examined the influence of variable position and bending stiffness of 1 quadrangle longitudinal filler on the panel shear resistance with the geometric state and its buckling behavior. Composite Grid Stiffened Structures sometimes has been of great enthusiasm as a substitution for Honeycomb Sandwich and Isogrid developments. However, for a long time, these were unused because of the enormous assembling and investigation challenges related to their development. Amid the previous 2 decades, the noteworthy advance has been made in the assembling of these structures. One of the critical outline factors in an AGS structure is rib thickness. These AGS structures can possibly dispose of a considerable lot of the issues related to honeycomb sandwich structures. In particular, dampness take-up is a notable issue for sandwich boards as the moisture gets caught in the cells of the sandwich structure and causes consumption. Framework structures, as every single other structure, have unmistakable advantages and downsides. While there has been critical lab involvement with these structures, true experience has been restricted and genuine operational experience is non-existent. In this manner, a portion of the apparent advantages and downsides of these structures are problematic.

From the literature review it was found that the good number of work have been done on buckling, post-buckling and ultimate strength of composite plate and stiffened composite plate subjected to shear, uniaxial or biaxial compressive, thermal load etc. But now here focusing mainly on grid type of structures no much research has been done.

Problem Description

The scope of the project is study of composite materials, design and analysis of grid stiffened composite flat panel with an orthogonal lattice pattern. Composite materials involve fiber reinforced plastics with material selection criteria. The design of flat panel includes geometrical parameter considerations of the stiffener, number of stiffeners, a lattice

pattern, size and shape of flat panel etc. Finite element method is used for analysis of flat panels.

The key objectives of the work are:

- Study of various grid stiffened composite structures of GFRP and CFRP composites at different loading conditions.
- Study of the Flat panel with an orthogonal lattice pattern.
- Design and analysis of grid stiffened Flat panel.
- Comparing the results.

2. METHODOLOGY

Finite element analysis software ANSYS 14.0 APDL (ANSYS Parametric Design Language) has been used for the analysis of composite grid plates within the gift work. During this, tool area unit variety of part varieties that is needed to model a stratified sort structure is required. During this analysis, shell 281 is chosen, because it is appropriate for analyzing skinny to moderately-thick structure, well-suited for giant rotation, has six degrees of freedom, seen in nonlinear giant strain and linear applications. The pure mathematics, part frame of reference, the node location and part consists of shell section data and eight nodes. ANSYS consists of solid to flexible and flexible to flexible contact element, for this it requires contact and target surface to make the contact pair between stiffener and plate. For giving proper bonding of these laminates here in this work CONTACT 174 and TARGET 170 has been used for the same.

Modeling

1.1. Modeling of Plate

To analyze the laminated composite plate it needs a platform that has facility to alter the orientation angle, thickness and layer for constant quantitative study in any finite component analysis. The plate has the dimensions shown below.

Table 1: Geometry Dimension of Thin Plate [1]

Length (a)	Width (b)	Thickness (h)
400 mm	400mm	1mm

The grid stiffened flat panel structure consists of layered construction. After preliminary analysis, lay up sequence has selected as [0◦] for the longitudinal layer, [0◦/90◦] for cross over layers and [90◦] for the transverse layers. This layup sequence refers to Uni-directional fabrics. Properties of the different materials used in the analysis are shown in the table:

Table 2:Mechanical Property of Isotropic Material

Property	Carbon Fiber Composite	Glass Fiber Composite
Modulus of elasticity (EX)	120GPA	35GPA
Modulus of elasticity (Ey)	7GPA	10GPA
Modulus of elasticity (Ez)	7GPA	10GPA
Shear modulus (GXY)	5GPA	6GPA
Shear modulus (GYZ)	2.5GPA	3GPA
Shear modulus (GXZ)	5GPA	6GPA
Poisons' ratio(Vx)	0.32	0.30
Poisons' ratio(Vy)	0.30	0.28
Poisons' ratio(Vz)	0.32	0.30

Table 2:Contd.,		
Density	1.5g/cc	2.1g/cc

The stiffened grid structure consists of different layups. The grid and a composite layer of the structure have different layup orientation. Each section of the grid structure has different layups.

Table 3: layups For the Carbon Epoxy Material

Area	Section Number	Lay Up Orientation
A1	1	90°
A2	2	$0^{\circ}/90^{\circ}$
A3	3	0°

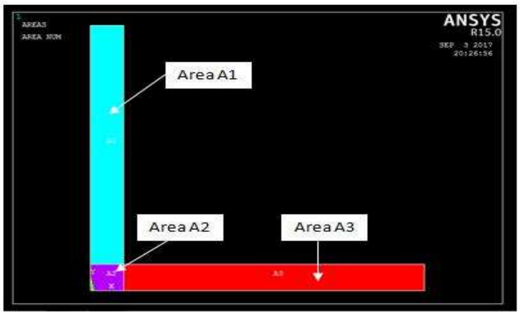

Figure 1: Different Areas of Grid Stiffened Plate

The finite element model is generated using Shell- 3D 4node 181 elements. The necessary partitions are made to make accurate meshing which satisfies the quality check of the elements. The meshed model of the elemental area has shown in figure. 2

After meshing the Elemental area with three areas it is copied as per the required grid structure. After meshing the grid structure a layer is generated on the grid with respect to the dimensions (410mm X 410 mm) shown in figure.3

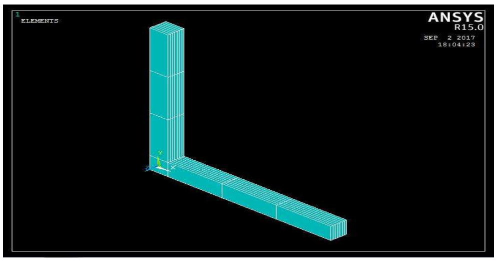

Figure 2: The Meshed Model of the Elemental Area

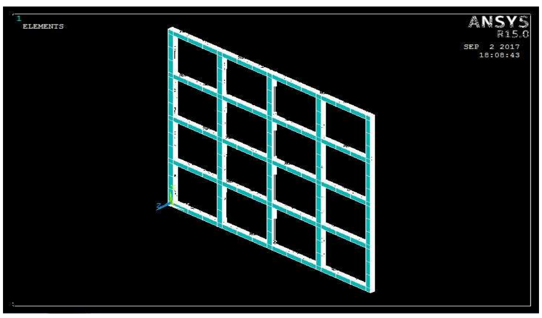

Figure 3: Meshed Grid Stiffened Structure

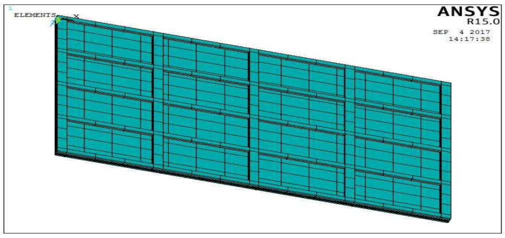

Figure 4: Meshed Grid Stiffened Flat Panel

The main boundary conditions of displacement are arrested at all sides of the nodes. Three different types of loads applied on each of the plate differently which are normal uniformly distributed load, buckling load and point load at the mid. In each of case, have to observe how the plate is deforming.

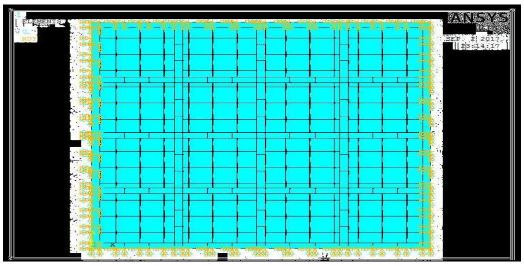

Figure 4.12: Grid Stiffened Flat Panel Subjected To Displacement at Nodes

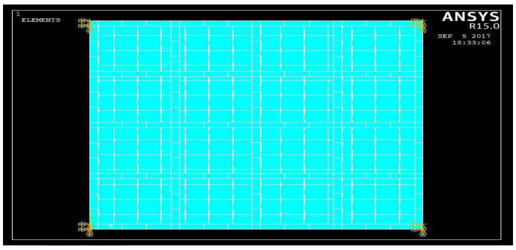

Figure 4.13: Grid Stiffened Flat Panel Subjected to Displacement on Edges

3. RESULTS AND DISCUSSION

Change of an object temporarily or permanently due to the applied forces is known as deformation. A deformation is caused by the external loads, body forces or change in temperature, moisture content or due to chemical reactions.

Deformation of Carbon and Glass

Comparison of the deformation vector sum between carbon and glass materials by varying loads.

Table 4: Deformation of Carbon and Glass with Varying Loads Subjected to Simple Loading

Load (N)	Carbon	Glass
200	1.3535	1.12748
400	2.7070	2.25496
600	4.0605	3.38244
800	5.4413	4.50993
1000	6.7676	5.53240
1200	8.1212	6.76492

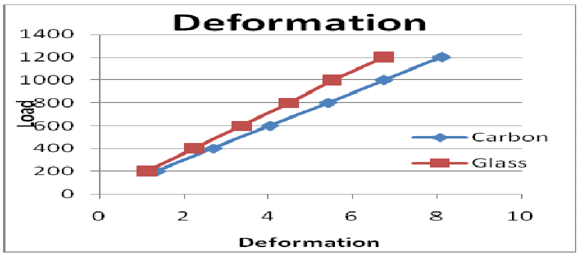

Figure 5: Deformation of Carbon and Glass

In displacement vector sum the deflection is more in the s-glass which proves that the carbon fiber shows more strength in same loading conditions.

Table 5: Stress of Carbon and Glass With Varying Loads Subjected to Simple Loading

Load (N)	Carbon	Glass
200	1255.63	1144.21
400	2511.25	2288.41
600	3766.88	3432.62
800	5022.5	4576.83
1000	6278.13	6165.29
1200	7533.75	6865.24

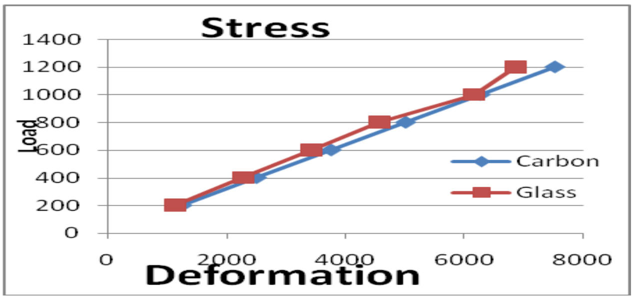

Figure 6: Stress of Carbon and Glass with Varying Loads Subjected to Simple Loading

The Stress is more in the s-glass which proves that the carbon fiber shows more strength in same loading conditions

Table 6: Shear Stress of Carbon and Glass Subjected to Simple Loading

Load (N)	Carbon	Glass
200	1.54E-13	1.40E-13
400	3.08E-13	2.80E-13
600	4.61E-13	4.20E-13
800	6.15E-13	5.60E-13
1000	7.69E-13	7.01E-13
1200	9.23E-13	8.41E-13

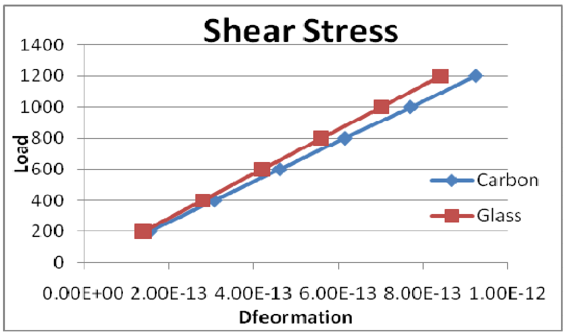

Figure 7: The Shear Stress of Carbon and Glass Subjected to Simple Loading

The shear stress shows that high stress is caused in Carbon fibre, which proves that the Carbon fibre can withstand more loading with respect to Glass.

Table 7: Deformation of Carbon and Glass with Varying Loads Subjected to Point Loading

Load (N)	Carbon	Glass
200	0.14822	0.12349
400	0.2964	0.2469
600	0.44468	0.370482
800	0.59291	0.54932
1000	0.741159	0.63472
1200	0.889407	0.740996

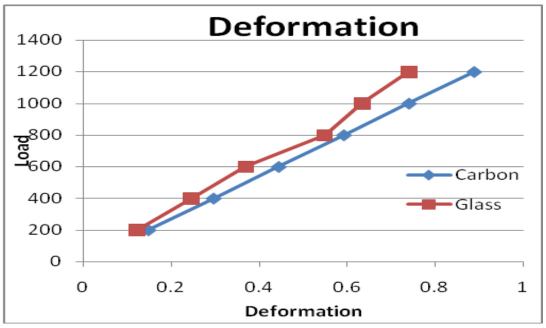

Figure 8: Deformation of Carbon and Glass Subjected to Point Loading

In displacement vector sum the deflection is more in the s-glass which proves that the carbon fibre shows more strength in same loading conditions

Table 8: Stress of Carbon and Glass with Varying Loads Subjected to Point Load

Load (N)	Carbon	Glass
200	112.74	103.731
400	225.48	207.463
600	338.22	311.194
800	450.96	414.925
1000	593.04	518.656
1200	676.44	622.388

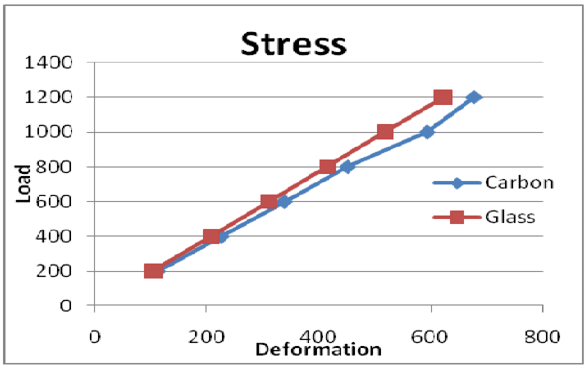

Figure 9: The Stress of Carbon and Glass with Varying Loads Subjected to Point Load

Carbon fiber can take more stress than that with respect to Glass which tells about the strength of Carbon fiber

Table 9: The Shear Stress of Carbon and Glass Subjected to Point Loading

Load (N)	Carbon	Glass
200	1.48E-14	1.44E-14
400	2.96E-14	2.87E-14
600	4.44E-14	4.31E-14
800	5.92E-14	5.74E-14
1000	7.40E-14	7.18E-14
1200	8.88E-14	8.62E-14

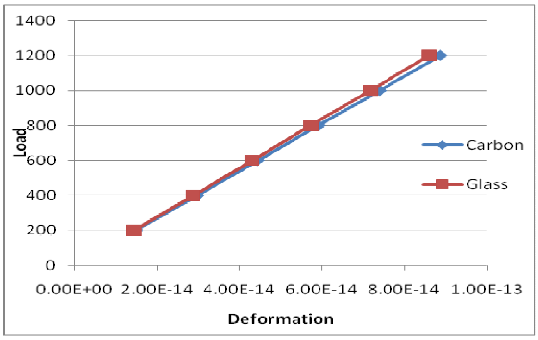

Figure 10: The Shear Stress of Carbon and Glass Subjected to Point Loading

The shear stress shows that high stress is caused in Carbon fibre which proves that the Carbon fibre can withstand more loading with respect to Glass.

Buckling Analysis of Carbon and Glass

Table 10: Buckling Load Factor and Eigen Value of Carbon

Load (N)	Buckling Load Factor	Eigen Value Buckling
1	5.8873	5887.3
1	5.8910	5891.0
1	6.4683	6468.3
1	6.9282	6928.2
1	10.709	10709
1	10.750	10750.0
1	13.704	13704

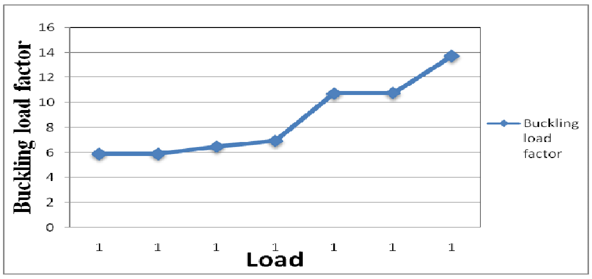

Figure 11: Buckling Load Factor Vs Eigen Value Buckling of Carbon

Table 11: Buckling Load Factor and Eigen Value of Glass

Load (N)	Buckling Load Factor	Eigen Value Buckling
1	2.5613	2561.3
1	2.5798	2579.8
1	3.1878	3187.8
1	3.3781	3378.1
1	5.62430	5624.3
1	5.7214	5721.4
1	5.7299	5729.9

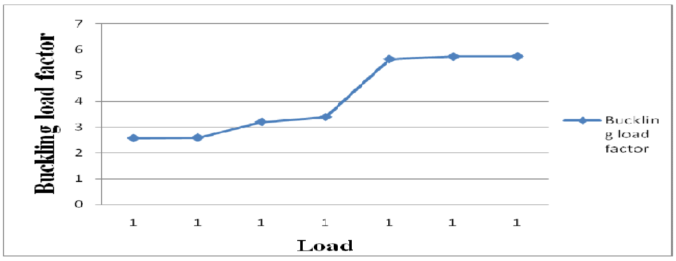

Figure 12: Buckling Load Factor Vs Eigen Value Buckling of Carbon

4. CONCLUSION

Simple Loading

- In displacement vector sum the deflection is more in the s-glass which proves that the carbon fibre shows more strength in same loading conditions.
- The Stress is more in the s-glass which proves that the carbon fibre shows more strength in same loading conditions.

Buckling Load

- Carbon fibre can take the buckling load with respect to Glass which tells about the strength of Carbon fibre.

Point Load

- Carbon fibre can take more stress than Glass which tells about the strength of Carbon fibre.
- The shear stress shows that high stress is caused in Carbon fibre which proves that the Carbon fibre can withstand more loading with respect to Glass.

REFERENCES

1. *Mallick P. K., Composite Engineering Handbook, 1997, Marcel Dekker Inc., NY, USA.*
2. *Gill, R. M., 1973, Carbon Fibers in Composite Materials, Page Bros (Norwich) Ltd, England.*
3. *Bhagavan D. Agarwal, Lawrence J. Broutman, K. Chandrashekara. Analysis andperformance of fiber composites. Wiley student edition.*
4. *Wang, D. and Abdalla , M. Buckling analysis of grid-stiffened composite shells. European Conference on Computational Fluid Dynamics 2002; 4173-4190.*
5. *Broekel, J., and GangadharaPrusty, B. Experimental and theoretical investigations on stiffened and unstiffened composite panels under uniform transverse loading. Composite Structures 2004; 63: 293–304.*
6. *Yucheng, L and Qingkui, W. Computational study of strengthening effects of stiffeners on regular and arbitrarily stiffened plates. Thin-Walled Structures 2012; 59:78–86.*
7. *El-Sawy, K. M. and Nazmy, A. S. Effect of aspect ratio on the elastic buckling of uniaxially loaded plates with eccentric holes. Thin-Walled Structures 2001; 39: 983–998.*
8. *Mechanical property of fibre glass and kevlar woven fabric reinforced composites, Composite Engineering, 1994; 5, 9: 1159-1175.*
9. *Kucher N K, Zemtsov M P, Zarazovskii M N. Deformation of laminated epoxy composites reinforced with high strengthfibres, Strength of Materials,2006; 38, 1.*
10. *José Ricardo Tarpani, Marcelo Tadeu Milan, Dirceu Spinelli, Waldek Wladimir Bose, Mechanical Performance of Carbon-epoxy Laminates Part II: 43 Quasi-static and Fatigue Tensile Properties, Materials Research, Vol. 9, No. 2, 2006, pp. 121-130.*
11. *G KRETSIS, —A review of the tensile, compressive, and flexural and shear properties of hybrid fiber reinforced plastics‖ Composites. Volume18. No 1. January 1987 pp 13-23.*
12. *C. Elanchezhian, B. Vijaya Ramnath, J. Hemalatha, —Mechanical behaviour of glass and carbon fibre reinforced composites at varying strain rates and temperatures‖ Procedia Materials Science (2014) 1405 – 1418.*